

**Thesis/
Reports
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**Effect of Deforestation by Tussock Moth on Timing,
Quantity, and Quality of Streamflow and Stream
Productivity Parameters**

Title: [Effect of deforestation by tussock moth on timing, quantity,
and quality of streamflow and stream productivity parameters

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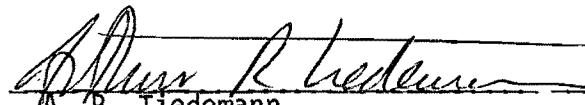
Performing Organizations:

- (1) Pacific Northwest Forest and Range Experiment Station
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- (2) Department of Biological Sciences
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Activity Number:

2.1.5 (1.1.2) with 4.1.1 Analyze effects of defoliation and
tree damage on ecological impacts

Approval:


A. R. Tiedemann Date 2-21-75
Project Leader

EFFECT OF DEFORESTATION BY TUSOCK MOTH ON TIMING, QUANTITY, AND QUALITY OF STREAMFLOW AND STREAM PRODUCTIVITY PARAMETERS

Objectives

- (1) What is the impact of deforestation by tussock moth and subsequent salvage harvest on quantity and timing of runoff?
- (2) What is the impact of deforestation by tussock moth and salvage harvest on quality of runoff, e.g. water temperature, stream chemistry, and microbiology?
- (3) How are stream productivity parameters affected by changes in quantity and quality of streamflow?

Approach to Problem Solution or Procedures

The study area will include representative areas in Washington and Oregon which were defoliated. Study of water yield relationships will be limited to areas where U.S. Geologic Survey records are available for analysis. Study of water quality changes will be conducted in the same general areas in order to make cross comparisons with the data.

Streamflow data published by the U.S. Geologic Survey will be analyzed for changes in annual and seasonal water yield as well as for changes in peak discharge rates. Various analytical techniques will be used including the double mass method. That is, a relationship will

be developed between data collected from an area affected by the moth and data from adjacent unaffected areas. Tests will be made to see if changes in this relationship coincide with the defoliation.

Sampling sites for chemical and microbiological water quality will be chosen to represent unit watershed conditions of natural forest, insect defoliation without salvage logging, and defoliation with salvage logging. Samples will be collected at approximately 9 sites (three replications of each established condition) on a monthly schedule. Samples will be analyzed for chemical constituents, pH, electrical conductivity, chemical oxygen demand, total alkalinity, bacterial populations (total coliform, fecal coliform, fecal streptococcus), and turbidity. Chemical constituents include nitrate-N, nitrite-N, ammonia-N, urea-N, total kjeldahl-N, total sulfate, phosphorus as ortho- and total phosphate, calcium, magnesium, potassium, and sodium. In undisturbed watersheds of the area, concentrations of nitrate-N, nitrite-N, ammonia-N, urea-N, and phosphate-P constituents are normally at concentrations less than 0.015 ppm, thus requiring careful and accurate laboratory analyses. Samples will be checked periodically for content of iron, aluminum, manganese, and zinc.

Sites for monthly measurements of stream productivity parameters will be selected within each watershed representing conditions described above. Chlorophyll analysis will be used as a measure of primary productivity. Effect of deforestation and salvage harvest on the aquatic nitrogen cycle will be evaluated through determinations of

nitrification and nitrogen fixation. Bacterial growth "in situ" will be used as an additional parameter for estimating stream productivity in response to chemical and physical water quality changes.

Stream temperature will be measured with a recording instrument located in a stream where the vegetation was not disturbed and another instrument in a stream draining a heavily infested area. In addition, other streams will be sampled intensively during mid-summer with hand-held thermometers. Data will be tested for effects of stream exposure by defoliated timber and effects of defoliation plus salvage logging.

Justification

Although not a planned forest cover manipulation, a large-scale natural disaster such as the Douglas-fir tussock moth outbreak in Oregon and Washington provides an opportunity to observe responses of forest ecosystems to upper limits of deforestation stress. Salvage harvest of timber, which normally follows such an outbreak, places additional stress on the system.

Knowledge gained from studies of environmental responses will have immediate value for decision-making regarding timber salvage operations and site rehabilitation in future outbreaks. Results will also relate to current forest management practices since salvage forest harvest is being conducted in much of the affected area.

Since large contiguous areas were defoliated by the tussock moth, water use by vegetation logically will decrease with a corresponding increase in water yield. The magnitude of these increases must be

established, along with possible changes in physical and chemical water quality, and stream productivity factors before the total impact of the infestation can be determined. Water yield may increase sufficiently to significantly offset the value of the lost timber since water is in short supply in the lowland areas where irrigation agriculture is a major industry.

However, the value of increased water yield will depend to a large extent on whether or not water quality, stream productivity, and peak discharge rates were adversely affected. Therefore, it will be necessary to sample for physical and chemical water quality changes and to analyze flow records for changes in peak discharge rates. If peak discharge rates increase, it may be necessary to protect stream banks in some areas in order to control channel cutting and prevent unacceptable increases in suspended sediment.

Studies will be coordinated with those currently in progress on the High Ridge evaluation watersheds of the Umatilla National Forest Barometer Watershed program. The Umatilla National Forest, Projects PNW-1701 and PNW-1601, and Central Washington State College are cooperating in a series of studies to evaluate impacts of forest harvest on factors of the forest environment in the Abies grandis tree zone in eastern Oregon. Currently, there are 10 studies in progress involving 12 scientists. Three years of background data on water quality and one year of stream benthos data will be used as reference information.

State of Knowledge

Past research at several locations in the U.S. has demonstrated that runoff from forested watersheds increases when more than about 25 percent of the trees are removed (Hibbert, 1965). Love (1955) reported a 2-inch increase in annual runoff from a watershed in Colorado after a bark beetle epidemic had killed forest trees on about 30 percent of the drainage area. A later analysis of the data by Bethlahmy (1974) indicated that yield had not returned to normal 25 years after the infestation. Bethlahmy's analysis also indicated an increase (27 percent) in peak discharge rate from the affected watershed.

Helvey (1971) reported average water yield increases of 3.3 inches (50 percent) and water temperature increases of 10° F. the first year after all vegetation on three watersheds in North-Central Washington was destroyed by wildfire. Water yield increases in later years were even greater (Helvey, 1972; Helvey et al. 1974), but record precipitation amounts prevented an accurate determination of the increase resulting from vegetation reduction alone. The first year after the fire, Tiedemann and Helvey (1973) observed that the nitrate nitrogen in streamflow from the experimental watersheds increased from background levels of 0.005 ppm to 0.07 ppm as a result of burning, and to 0.2 ppm as a result of burning followed by urea fertilization. During the second year, peak nitrate nitrogen concentration increased to over 0.5 ppm as a result of burning and to 1.5 ppm with burning followed by urea fertilization.

No results of changes in water yield, water temperature, bacterial populations, or stream productivity parameters following insect deforestation have been reported for eastern Oregon or eastern Washington. Thus, the research proposed here is expected to add significantly to our knowledge about watershed behavior after deforestation and salvage logging.

Duration

Water yield studies will begin in spring of 1975 and will be essentially finished by December 1975. Water quality and stream productivity investigations will begin in April 1975 with a completion date in September 1976.

Personnel

Principal Investigator, Water Yield: Mr. J. D. Helvey, Principal Forest Hydrologist, Project PNW 1601, Wenatchee, Washington.

Principal Investigator, Water Quality, Dr. A. R. Tiedemann, Project Leader and Principal Range Scientist, Project PNW 1601, Wenatchee, Washington.

Dr. Dennis Swanger, Instructor, Department of Biological Sciences, Central Washington State College, Ellensburg, Washington.

Dr. Robert Pacha, Professor, Department of Biological Sciences, Central Washington State College, Ellensburg, Washington.

Technical Assistance

B. K. Van Hoven, Forestry Technician (GS-7)

Facilities and Equipment

Water yield analysis: To be done by

Forest Hydrology Laboratory personnel.

140 technician man-days at GS-5

15 scientist man-days at GS-13

Sub-total

\$ 4,480

1,260

5,740

Water quality analysis: To be

contracted as cooperative aid proposal

or research contract with Central

Washington State College for 18 months

duration

Period April 1975 through March 1976

Salaries:

Study Leader full time during
summer 1975, and 10% during
academic year

3,880

Research assistant full time
12 months

4,555

Indirect costs (15% of salaries)

1,265

Employee benefits

1,040

reduced to
60 days

Equipment: All terrain vehicle
and trailer for winter access to
study sites

4,600

1500
lease

Supplies

1,500

Travel - 12 trips to Blue

Mountains; 12 trips to Colville area

5,000

Travel for Forest Hydrology

Laboratory personnel to assist
in selection of study sites and
research coordination

1,000

28,580

Period April 1976 through September 1976

Salaries:

Study Leader full time

7,375

Research assistant full time

2,278

Indirect costs (15% of salaries)

1,448

Employee benefits

1,334

Supplies

750

Travel

2,500

Total

\$44,265

-3100

\$200/trip

Institutional Units Involved

Department of Biological Sciences, Central Washington State
College, Ellensburg, Washington

Cooperation

Selection of sample sites will be made in cooperation with National Forest Administration personnel.

Research and Development Impacts

- (1) Results will be necessary for evaluating economic impacts of the defoliation and subsequent salvage logging. For example, if the results indicate increases in runoff without deterioration in water quality, the deforestation will have a positive value in terms of water and will partially offset losses of timber volume.
- (2) Results will add to scientific knowledge concerning effects of vegetation changes on the hydrologic cycle in eastern Oregon and Washington. Such information is necessary for assessing environmental impacts of various forest activities.

Literature Cited

Bethlahmy, N. 1974. A Colorado episode: Beetle epidemic, ghost forest, more streamflow. Paper presented at 47th Annual Meeting of the Northwest Scientific Association, Univ. of B. C., Vancouver.

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Love, L. D. 1955. The effect on streamflow of the killing of spruce and pine by the Engelmann spruce beetle. Trans. Amer. Geophys. Union 36(1): 113-118.

Tiedemann, A. R., and J. D. Helvey. 1973. Nutrient ion losses in streamflow after fire and fertilization in eastern Washington. (Abstr.) Bull. Ecol. Soc. Amer. 54(1): 20.